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UTILITY PATENT APPLICATION TRANSMITTAL
(Small Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
1009.004CIP
Total Pages in this Submission
29

06/24/99 EL778505446US PTO

TO THE ASSISTANT COMMISSIONER FOR PATENTS
Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

PREFERRED EMBODIMENT TO LED LIGHT STRING

JC549 U.S. PTO 09/339616 06/24/99

and invented by:

MARK R. ALLEN

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

☐ **Continuation** ☐ **Divisional** ☒ **Continuation-in-part (CIP)** of prior application No.: **09/141,914**

Which is a:

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Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having **15** pages and including the following:
   a. ☒ Descriptive Title of the Invention
   b. ☒ Cross References to Related Applications *(if applicable)*
   c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
   d. ☐ Reference to Microfiche Appendix *(if applicable)*
   e. ☒ Background of the Invention
   f. ☒ Brief Summary of the Invention
   g. ☒ Brief Description of the Drawings *(if drawings filed)*
   h. ☒ Detailed Description
   i. ☒ Claim(s) as Classified Below
   j. ☒ Abstract of the Disclosure

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Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
   a. ☐ Formal b. ☒ Informal Number of Sheets 5
4. ☒ Oath or Declaration
   a. ☒ Newly executed *(original or copy)* ☐ Unexecuted
   b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
   c. ☐ With Power of Attorney ☐ Without Power of Attorney
   d. ☐ *DELETION OF INVENTOR(S)*
   Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. ☐ Computer Program in Microfiche
7. ☐ Genetic Sequence Submission *(if applicable, all must be included)*
   a. ☐ Paper Copy
   b. ☐ Computer Readable Copy
   c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☒ Assignment Papers *(cover sheet & documents)*
9. ☐ 37 CFR 3.73(b) Statement *(when there is an assignee)*
10. ☐ English Translation Document *(if applicable)*
11. ☐ Information Disclosure Statement/PTO-1449 ☐ Copies of IDS Citations
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Accompanying Application Parts (Continued)

15. ☐ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*

16. ☒ Small Entity Statement(s) - Specify Number of Statements Submitted: 1

17. ☐ Additional Enclosures *(please identify below):*

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra		Rate	Fee
Total Claims	28	- 20 =	8	x	$9.00	$72.00
Indep. Claims	1	- 3 =	0	x	$39.00	$0.00
Multiple Dependent Claims (check if applicable) ☐						$0.00
					BASIC FEE	$380.00
OTHER FEE *(specify purpose)*		**RECORDATION FORM COVER SHEET**				$40.00
					TOTAL FILING FEE	$492.00

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☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. **23-0813** as described below. A duplicate copy of this sheet is enclosed.

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- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

Dated: **JUNE 24,1999**

Signature

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STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(c))--SMALL BUSINESS CONCERN	Docket Number (Optional) 1009.004CIP

Applicant, Patentee, or Identifier: Mark R. Allen
Application or Patent No.:
Filed or Issued:
Title: PREFERRED EMBODIMENT TO LED LIGHT STRING

I hereby state that I am
☐ the owner of the small business concern identified below:
☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN Fiber Optic Designs, Inc.

ADDRESS OF SMALL BUSINESS CONCERN 704 Floral Vale Boulevard, Yardley, PA 19067

I hereby state that the above identified small business concern qualifies as a small business concern as defined in 13 CFR Part 121 for purposes of paying reduced fees to the United States Patent and Trademark Office. Questions related to size standards for a small business concern may be directed to: Small Business Administration, Size Standards Staff, 409 Third Street, SW, Washington, DC 20416.

I hereby state that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in.

☒ the specification filed herewith with title as listed above.
☐ the application identified above.
☐ the patent identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern, or organization having rights in the invention must file separate statements as to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern, or organization having any rights in the invention is listed below:
☐ no such person, concern, or organization exists.
☐ each such person, concern, or organization is listed below.

Separate statements are required from each named person, concern or organization having rights to the invention stating their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance

NAME OF PERSON SIGNING David R. Allen

TITLE OF PERSON IF OTHER THAN OWNER President

ADDRESS OF PERSON SIGNING

SIGNATURE [signature] DATE 6/21/99

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Attorney Docket No. 1009.004CIP

APPLICATION FOR UNITED STATES LETTERS PATENT

FOR

PREFERRED EMBODIMENT TO LED LIGHT STRING

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* * * * * *

Certification Under 37 CFR 1.10

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I hereby certify that this document is being deposited with the United States Postal Service's "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

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Therese McKinley (Signature of person mailing)

Preferred Embodiment to Led Light String

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of copending application serial number 09/141,914 filed August 28, 1998, titled LED LIGHT STRING EMPLOYING SERIES-PARALLEL BLOCK COUPLING and bearing Attorney Docket No. 1009.002, the entire disclosure of which copending application is incorporated herein by reference. This application claims benefit of U.S. Provisional Application No. 60/119,804, filed February 12, 1999.

BACKGROUND OF THE INVENTION

Field of Invention

The present invention relates to light strings and, more particularly, to decorative light strings employing LEDs.

Description of Related Art

Light emitting diodes (LEDs) are increasingly employed as a basic lighting source in a variety of forms, including decorative lighting, for reasons among the following. First, as a device, LEDs have a very long lifespan, compared with common incandescent and fluorescent sources, with typical LED lifespan at least 100,000 hours. Second, LEDs have several favorable physical properties, including ruggedness, cool operation, and ability to operate under wide temperature variations. Third, LEDs are currently available in all primary and several secondary colors, as well as in a "white" form employing a blue source and phosphors. Fourth, with newer doping techniques, LEDs are becoming increasingly efficient, and colored LED sources currently available may consume an order of magnitude less power than incandescent bulbs of equivalent light output. Finally, with expanding applications and resulting larger volume demand, as well as with new manufacturing techniques, LEDs are increasingly cost effective.

LED-based light strings, used primarily for decorative purposes such as for Christmas lighting, is one application for LEDs. For example, U.S. patent 5,495,147 entitled LED LIGHT STRING

SYSTEM to Lanzisera (hereinafter "Lanzisera") and U.S. patent 4,984,999 entitled STRING OF LIGHTS SPECIFICATION to Leake (hereinafter "Leake") describe different forms of LED-based light strings. In both Lanzisera and Leake, exemplary light strings are described employing purely parallel wiring of discrete LED lamps using a step-down transformer and rectifier power conversion scheme. These and all other LED light string descriptions found in the prior art convert input electrical power, usually assumed to be the common U.S. household power of 110 VAC to a low voltage, nearly DC input. The present invention relaxes this input electrical power conversion and specifies a preferred embodiment in which the LED light string is electrically powered directly from either a common household 110 VAC or 220 VAC source, without a lower voltage involved via power conversion. The LEDs may be driven using household AC, rather than DC, because the nominal LED forward bias voltage, if used in reverse bias fashion, is generally much lower than the reverse voltage where the LED p-n junction breaks down. When LEDs are driven by AC, pulsed light is effected at the AC rate (e.g., 60 or 50 Hz), which is sufficiently high in frequency for the human eye to integrate and see as a continuous light stream.

SUMMARY OF THE INVENTION

The present invention relates to a light string, including a pair of wires connecting to a standard household AC electrical plug; a plurality of LEDs powered by the pair of wires, wherein the LEDs are electrically coupled in series to form at least one series block; multiple series blocks, if employed, that are electrically coupled in parallel; a standard household AC socket at the opposite end for connection of multiple light strings in an end-to-end, electrically parallel fashion.

BRIEF DESCRIPTION OF THE DRAWINGS

Other aspects, features and advantages of the present invention will become more fully apparent from the following detailed description, the appended claims, and the accompanying drawings in which:

FIG. 1 shows two example block diagrams of the light string in its embodiment preferred primarily, with one diagram for a 110 VAC common household input electrical source (e.g., 60 Hz) and one diagram for a 220 VAC common household (e.g., 50 Hz) input electrical source.

FIG. 2 shows two example schematic diagrams of the light string corresponding to the two block diagrams in FIG. 1 for either the 110 VAC or the 220 VAC input electrical source.

FIG. 3 shows two example block diagrams of the light string in its embodiment preferred alternatively, with one diagram for a 110 VAC common household input electrical source (e.g., 60 Hz) and one diagram for a 220 VAC common household (e.g., 50 Hz) input electrical source.

FIG. 4 shows an example schematic diagram of the AC-to-DC power supply corresponding to the two block diagrams in FIG. 3 for either the 110 VAC or the 220 VAC input electrical source.

FIG. 5 shows an example pictorial diagram of the manufactured light string in either its "straight" or "curtain" form (either form may be manufactured for 110 VAC or 220 VAC input).

FIG. 6 shows an example pictorial diagram of special tooling of the housing for an LED housing in the light string, for assurance of proper LED electrical polarity throughout the light string circuit.

FIG. 7 shows an example pictorial diagram of special tooling and manufacturing of the LED and its housing in the light string, for assurance of proper LED polarity using the example in FIG. 6.

FIG. 8 shows an example pictorial diagram of a fiber optic "icicle" attached to an LED and its housing in the light string, where the "icicle" diffuses the LED light in a predetermined manner.

DETAILED DESCRIPTION

The term "alternating current voltage", sometimes abbreviated as "VAC", as used herein occasionally refers to a numerical amount of volts, for example, "220 VAC". It is to be understood that the stated number of alternating current volts is the nominal voltage which cycles continuously in forward and reverse bias and that the actual instantaneous voltage at a given point in time can differ from the nominal voltage number.

In accordance with the present invention, an LED light string employs a plurality of LEDs wired in series-parallel form, containing at least one series block of multiple LEDs. The series block size is

determined by the ratio of the standard input voltage (e.g., either 110 VAC or 220 VAC) to the drive voltage(s) of the LEDs to be employed (e.g., 2 VDC). Further, multiple series blocks, if employed, are each of the same LED configuration (same number and kinds of LEDs), and are wired together along the string in parallel. LEDs of the light string may comprise either a single color LED or an LED including multiple sub-dies each of a different color. The LED lenses may be of any shape, and may be either clear, clear-colored, or diffuse-colored. Moreover, each LED may have internal circuitry to provide for intermittent on-off blinking and/or intermittent LED sub-die color changes. Individual LEDs of the light string may be arranged continuously (using the same color), or periodically (using multiple, alternating colors), or pseudo-randomly (any order of multiple colors). The LED light string may provide an electrical interface to couple multiple lights strings together in parallel, and physically from end to end. Fiber optic bundles or strands may also be coupled to individual LEDs to diffuse LED light output in a predetermined manner.

An LED light string of the present invention may have the following advantages. The LED light string may last far longer and require less power consumption than light strings of incandescent lamps, and they may be safer to operate since less heat is generated. The LED light string may have reduced cost of manufacture by employing series-parallel blocks to allow operation directly from a standard household 110 VAC or 220 VAC source, either without any additional circuitry (AC drive), or with only minimal circuitry (DC drive). In addition, the LED light string may allow multiple strings to be conveniently connected together, using standard 110 VAC or 220 VAC plugs and sockets, desirably from end-to-end.

Direct AC drive of LED light string avoids any power conversion circuitry and additional wires; both of these items add cost to the light string. The additional wires impose additional mechanical constraint and they may also detract aesthetically from the decorative string. However, direct AC drive results in pulsed lighting. Although this pulsed lighting cannot be seen at typical AC drive frequencies (e.g. 50 or 60 Hz), the pulsing itself is not the most efficient use of each LED device because less overall light is produced than if the LEDs were continuously driven using DC. This lower amount of light produced may be compensated for by using more expensive, brighter LEDs, and thus an engineering tradeoff exists, where AC drive is of primary preference, and DC drive is preferred alternatively.

FIG. 1 shows the embodiment of an LED light string in accordance with the present invention, and as preferred primarily through AC drive. In FIG. 1, the two block diagrams correspond to a exemplary string employing 100 LEDs, for either 110 VAC (top diagram) or 220 VAC (bottom diagram) standard household current input (e.g., 50 or 60 Hz). In the top block diagram of FIG. 1, the input electrical interface consists merely of a standard 110 VAC household plug **101** attached to a pair of drive wires. With the average LED drive voltage assumed to be approximately 2.2 V in FIG. 1, the basic series block size for the top block diagram, corresponding to 110 VAC input, is approximately 50 LEDs. Thus, for the 110 VAC version, two series blocks of 50 LEDs **102** are coupled in parallel to the drive wires along the light string. The two drive wires for the 110 VAC light string terminate in a standard 110 VAC household socket **103** to enable multiple strings to be connected in parallel electrically from end-to-end.

In the bottom block diagram of FIG. 1, the input electrical interface likewise consists of a standard 220 VAC household plug **104** attached to a pair of drive wires. With again the average LED drive voltage assumed to be approximately 2.2 V in FIG. 1, the basic series block size for the bottom diagram, corresponding to 220 VAC input, is 100 LEDs. Thus, for the 220 VAC version, only one series block of 100 LEDs **105** is coupled to the drive wires along the light string. The two drive wires for the 220 VAC light string terminate in a standard 220 VAC household socket **106** to enable multiple strings to be connected in parallel from end-to-end. Note that for either the 110 VAC or the 220 VAC light string, the standard plug and socket employed in the string varies in accordance to the country in which the light string is intended to be used.

As an alternative preference to AC drive, FIG. 3 shows two block diagrams that correspond to a exemplary string employing 100 LEDs and DC drive, for either 110 VAC (top diagram) or 220 VAC (bottom diagram) standard household current input (e.g., 50 or 60 Hz). In the top block diagram of FIG. 3, the input electrical interface consists of a standard 110 VAC household plug **301** attached to a pair of drive wires, followed by an AC-to-DC converter circuit **302**. As in FIG. 1, with the average LED drive voltage assumed to be approximately 2.2 V in FIG. 3, the basic series block size for the top block diagram, corresponding to 110 VAC input, is approximately 50 LEDs. Thus, for the 110 VAC version, two series blocks of 50 LEDs **303** are coupled in parallel to the output of the AC-to-DC converter **302** using additional feed wires along the light string. The two drive wires for the 110 VAC light string

terminate in a standard 110 VAC household socket **304** to enable multiple strings to be connected in parallel electrically from end-to-end.

In the bottom block diagram of FIG. 3, the input electrical interface likewise consists of a standard 220 VAC household plug **305** attached to a pair of drive wires, followed by an AC-to-DC converter circuit **306**. With again the average LED drive voltage assumed to be approximately 2.2 V in FIG. 3, the basic series block size for the bottom diagram, corresponding to 220 VAC input, is 100 LEDs. Thus, for the 220 VAC version, only one series block of 100 LEDs **307** is coupled to the output of the AC-to-DC converter **307** using additional feed wires along the light string. The two drive wires for the 220 VAC light string terminate in a standard 220 VAC household socket **308** to enable multiple strings to be connected in parallel from end-to-end. Note that for either the 110 VAC or the 220 VAC light string, the standard plug and socket employed in the string varies in accordance to the country in which the light string is intended to be used.

FIG. 4 shows an example schematic electrical diagram for the AC-to-DC converter employed in both diagrams of FIG. 3. The AC input to the circuit in FIG. 1 is indicated by the symbol for an AC source **401**. A varistor **402** may optionally be used to ensure that voltage is limited during power surges. The actual AC to DC rectification is performed by use of a full-wave bridge rectifier **403**. This bridge rectifier **403** results in a rippled DC current and therefore serves as an example circuit only. A different rectification scheme may be employed, depending on cost considerations. For example, one or more capacitors or inductors may be added to reduce ripple at only minor cost increase. Because of the many possibilities, and because of their insignificance, these and similar additional circuit features have been purposely omitted from FIG. 4.

For either the 110 VAC or the 220 VAC version of the LED light string, and whether or not an AC-to-DC power converter is used, the final manufacturing may be a variation of either the basic "straight" string form or the basic "curtain" string form, as shown in the top and bottom pictorial diagrams in FIG. 5. In the basic "straight" form of the light string, the standard (110 VAC or 220 VAC) plug **501** is attached to the drive wires which provide power to the LEDs **502** via the series-parallel feeding described previously. The two drive and other feed wires **503** are twisted together along the length of the light string for compactness and the LEDs **502** in the "straight" form are aligned with these twisted wires **503**, with the LEDs **502** spaced uniformly along the string length (note drawing is not to

scale). The two drive wires in the "straight" form of the light string terminate in the standard (correspondingly, 110 VAC or 220 VAC) socket **504**. Typically, the LEDs are spaced uniformly every four inches.

In the basic "curtain" form of the light string, as shown pictorially in the bottom diagram of FIG. 5, the standard (110 VAC or 220 VAC) plug **501** again is attached to the drive wires which provide power to the LEDs **502** via the series-parallel feeding described previously. The two drive and other feed wires **503** are again twisted together along the length of the light string for compactness. However, the feed wires to the LEDs are now twisted and arranged such that the LEDs are offset from the light string axis in small groups (groups of 3 to 5 are shown as an example). The length of these groups of offset LEDs may remain the same along the string or they may vary in either a periodic or pseudo-random fashion. Within each group of offset LEDs, the LEDs **502** may be spaced uniformly as shown or they may be spaced nonuniformly, in either a periodic or pseudo-random fashion (note drawing is not to scale). The two drive wires in the "curtain" form of the light string also terminate in a standard (correspondingly 110 VAC or 220 VAC) socket **504**. Typically, the LED offset groups are spaced uniformly every six inches along the string axis and, within each group, the LEDs are spaced uniformly every four inches.

In any above version of the preferred embodiment to the LED light string, blinking may be obtained using a number of techniques requiring additional circuitry, or by simply replacing one of the LEDs in each series block with a blinking LED. Blinking LEDs are already available on the market at comparable prices with their continuous counterparts, and thus the light string may be sold with the necessary (e.g., one or two) additional blinkers included in the few extra LEDs.

In wiring any version of the preferred embodiment to the light string, as described previously, it is critical that each LED is powered using the correct LED polarity. This equates to all feeds coming from the same drive wire always entering either the positive or the negative lead of each LED. Since the drive wires are AC, it does not matter whether positive or negative is chosen initially – it is only important all the LEDs in each series block have the same polarity orientation (either all positive first or all negative first). In order to facilitate ease of proper manufacturing, as well as ease of proper LED bulb replacement by the user, each LED and its assembly into its housing may be modified to insure proper polarity. An example modification is shown in FIG. 6, where the LED (shown at far left with

a rectangular, arched-top lens) is modified to include a keyed offset on its base **601**, and accordingly, the LED lamp base incorporates a notch **602** to accommodate this keyed offset. This first pair of modifications, useful for manufacturing only, results in the LED being properly mounted within its base to form replaceable LED lamp bulb. In order to properly fit this replaceable LED lamp bulb into its holder on the light string, the lamp base is also modified to include a keyed offset on its base **603**, and the lamp holder is correspondingly notched **604** for proper alignment. This second pair of modifications is useful in both manufacturing and by the user, for properly placing or replacing the LED lamp bulb into its holder on the light string. The LED lamp base and holder collectively form the LED housing.

In manufacturing the above modification to assure proper LED polarity, it may be advantageous to build the LED mold such that two piece replaceable LED lamp bulb described in FIG. 6 can be made in one step as a single piece. This is illustrated in FIG. 7, where the single piece replaceable LED lamp bulb **701** has a single keyed offset to fit into its notched lamp holder **702**. Although this requires more elaborate modification of the LED base, the resulting assembly is now composed of two, rather than three, LED pieces and as such, may allow the lights string to be made more rapidly and at lower cost.

Typically, the LEDs in the light string will incorporate a lens for wide-angle viewing. However, it is also possible to attach fiber optic bundles or strands to the LEDs to spatially diffuse the LED light in a predetermined way for a visual effect. In such case, the LED lens is designed to create a narrow-angle light beam (e.g., 20 degree beamwidth) along its axis, to enable the LED light to flow through the fiber optics with high coupling efficiency. An example of the use of fiber optics is shown in FIG. 8, where a very lossy fiber optic rod is employed with intention for the fiber optic rod to glow like an illuminated "icicle." In FIG. 8, the LED **801** and its housing **802** may be attached to the fiber optic rod **803** using a short piece of tubing **804** that fits over both the LED lens and the end of the fiber optic rod (note that the drawing is not to scale). An example design uses a cylindrical LED lens with a narrow-angle end beam, where the diameter of the LED lens and the diameter of the fiber optic rod are the same (e.g., 5 mm or 3/16 inches). The fiber optic rod **803** is typically between three to eight inches in length and may be either uniform in length throughout the light string, or the fiber optic rod length may vary in either a periodic or pseudo-random fashion.

Although the fiber optic rod **803** in FIG. 8 may be constructed using a variety of plastic or glass materials, it is preferred that the rod be made in either a rigid form using clear Acrylic plastic or clear

crystal styrene plastic, or in a highly flexible form using Polyvinyl Chloride (PVC) plastic. These plastics are preferred for safety, durability, light transmittance, and cost reasons. It may be desirable to add into the plastic rod material either air bubbles or other constituents, such as tiny metallic reflectors, to achieve the designed measure of lossiness for off-axis glowing (loss) versus on-axis light conductance. Moreover, if PVC or crystal styrene are to be used, it may be desirable to add UV inhibiting chemicals such as a combination of hindered amine light stabilizer (HALS) chemicals. The tubing **804** that connects the fiber optic rod **803** to its LED lens **801** may also made from a variety of materials, and be specified in a variety of ways according to opacity, inner diameter, wall thickness, and flexibility. From safety, durability, light transmittance, and cost reasons, it is preferred that the connection tubing **804** be a short piece (e.g., 10 mm in length) of standard clear flexible PVC tubing (containing UV inhibiting chemicals) whose diameter is such that the tubing fits snugly over both the LED lens and the fiber optic rod (e.g., standard wall tubing with 1/4 inch outer diameter). An adhesive may be used to hold this assembly more securely.

It will be understood that various changes in the details, materials and arrangements of the parts which have been described and illustrated in order to explain the nature of this invention may be made by those skilled in the art without departing from the principle and scope of the invention as expressed in the following claims.

CLAIMS

What is claim is:

1. A light string comprising:

a plurality of light emitting diodes "LEDs" electrically coupled in series to form at least one series block, each series block being electrically coupled in parallel between each of a pair of wires having a source end and a terminal end, intermediate the source end and the terminal end, and

a first connector electrically connected at the source end which connector is adapted for direct electrical connection to an alternating current electrical power supply.

2. The light string of claim 1 in which the light string is adapted to accept alternating current electricity without an intervening conversion to direct current electricity.

3. The light string of claim 2 further comprising a pair of wires supporting the LEDs between the source end and the terminal end.

4. The light string of claim 1 in which the electrical power supply provides alternating current having an alternating current voltage of at least about 110 volts.

5. The light string of claim 4 in which each LED has a p-n junction defining a break down voltage above which voltage applied in reverse bias said p-n junction breaks down, and in which light string the alternating current voltage is less than the break down voltage.

6. The light string of claim 5 in which the alternating current voltage is in the range of about 110-220 volts.

7. The light string of claim 1 in which the alternating current has a frequency effective to cause each LED to emit pulsed light which the human eye perceives as continuous.

8. The light string of claim 7 in which the frequency is at least about 50 Hz.

9. The light string of claim 1 in which the first connector is polarized, and which light string further comprises a second polarized connector electrically connected to the pair of wires at the terminal end, said second polarized connector being adapted to couple with a first polarized connector of another light string, thereby providing for coupling of multiple light strings in an end-to-end arrangement.

10. The light string of claim 1 in which the number of LEDs of each series block is at most a maximum number determined by the electrical power supply.

11. The light string of claim 1 in which each LED has a corresponding light output color and all of the LEDs in each series block is either of the same color or of different colors.

12. The light string of claim 11 in which the LED's in each series block are arranged by color either in a non-random order or a pseudo-random order.

13. The light string of claim 11 in which at least one LED comprises a housing and a fiber-optic bundle removably mounted to the housing operative to diffuse light output of the LED through the fiber-optic bundle.

14. The light string of claim 1 in which the LED are offset from the wires and arranged relative to a wire axis.

15. The light string of claim 14 in which each LED is arranged parallel to the wires to create a straight arrangement.

16. The light string of claim 15 in which the LEDs in each series block are uniformly spaced apart.

17. The light string of claim 14 in which the LEDs are arranged in offset groupings, each offset grouping having a length relative to the LEDs therein, and are arranged perpendicular to the wires to create a light string having a curtain arrangement, wherein the light string is comprised of offset groupings which are spaced either uniformly or nonuniformly in either a periodic or pseudo-random arrangement.

18. The light string of claim 17, wherein the LEDs are uniformly spaced by a first distance within an offset grouping and each offset grouping is uniformly spaced by a second distance along the drive wire axis.

19. The light string of claim 1, wherein the lamp holder and the lamp base of the LEDs are adapted to comprise cooperative notches or keyed offsets for setting the lamp holder into the lamp base and thereby orienting and aligning the LED by its polarity.

20. The light string of claim 1, wherein the lamp assembly of the LEDs is adapted to comprise cooperative notches or keyed offsets for setting the lamp bulb into the lamp assembly and thereby orienting and aligning the LED by its polarity onto the lamp holder on the light string.

21. The light string of claim 6, wherein the ac source is 220 VAC.

22. The light string of claim 21, wherein the maximum number of LEDs in a series block is 100.

23. The light string of claim 6, wherein the ac source is 110 VAC.

24. The light string of claim 23, wherein the maximum number of LEDs in a series block is 50.

25. The light string of claim 1, wherein the light string comprises a plurality of series blocks.

26. The light string of claim 9, wherein the first polarized connector is a polarized plug.

27. The light string of claim 26, wherein the second polarized connector is a polarized socket.

28. The light string of claim 1, wherein a light string further comprises a lossy fiber optic rod, having a diameter equal to a diameter of a corresponding LED lens, and a fiber housing, wherein the fiber housing adaptably receives the rod and LED lens into opposing ends, cooperatively, thereby creating an optical icicle feature.

ABSTRACT OF THE DISCLOSURE

An LED light string employs a plurality of LEDs wired in block series-parallel, where the one or more series blocks, each driven at the same input voltage as the source voltage (110 VAC or 220 VAC), are coupled in parallel. The LED light string interfaces to the source voltage using a common household plug; it may also include a corresponding common, household socket, coupled in electrical parallel, to enable multiple light strings to be connected to each other from end to end; it may also include AC-to-DC power conversion circuitry. LEDs of the light string may comprise either a single color LED or an LED including multiple sub-dies each of a different color. The LED lenses may be of any shape, and may be either clear, clear-colored, or diffuse-colored. Moreover, each LED may have internal circuitry to provide for intermittent on-off blinking and/or intermittent LED sub-die color changes. Individual LEDs of the light string may be arranged continuously (using the same color), or periodically (using multiple, alternating colors), or pseudo-randomly (any order of multiple colors). Fiber optic bundles or strands may also be coupled to individual LEDs to diffuse LED light output in a predetermined manner.

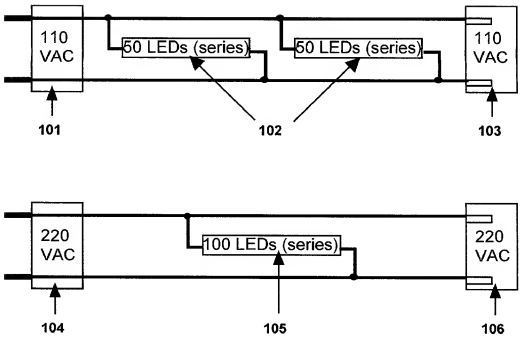

110
VAC
50 LEDs (series)
50 LEDs (series)
110
VAC
101
102
103
220
VAC
100 LEDs (series)
220
VAC
104
105
106

FIG. 1

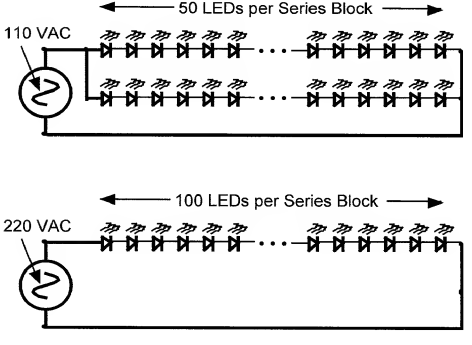

50 LEDs per Series Block
110 VAC
100 LEDs per Series Block
220 VAC

FIG. 2

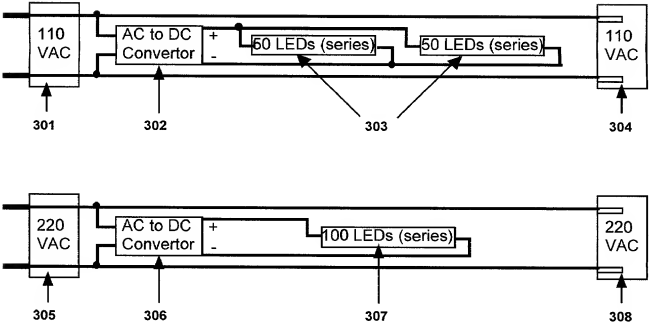

110
VAC
AC to DC
Convertor
+
-
50 LEDs (series)
50 LEDs (series)
110
VAC
301
302
303
304
220
VAC
AC to DC
Convertor
+
-
100 LEDs (series)
220
VAC
305
306
307
308

FIG. 3

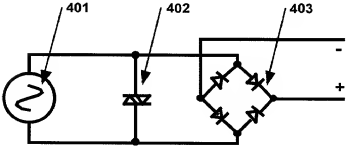
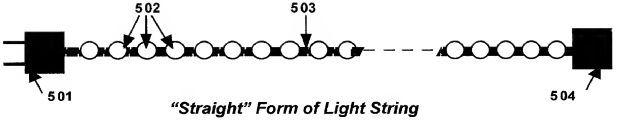
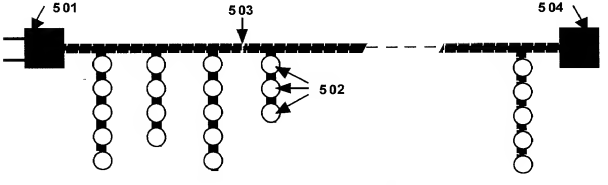

401
402
403
-
+

FIG. 4



"Straight" Form of Light String



"Curtain" Form of Light String

FIG. 5

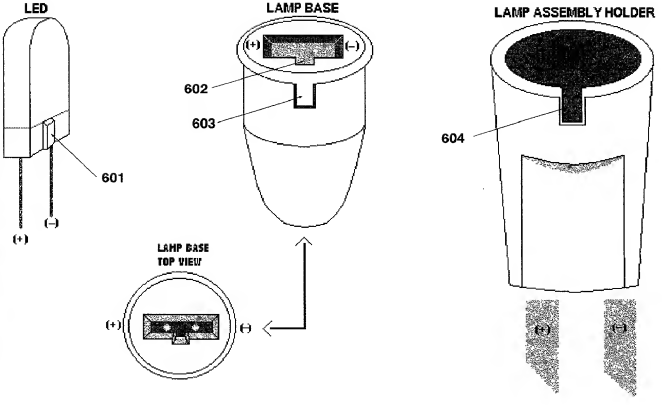

LED
601
(+)
(–)
LAMP BASE
602
603
(+)
(–)
LAMP BASE
TOP VIEW
(+)
(–)
LAMP ASSEMBLY HOLDER
604
(+)
(–)

FIG. 6

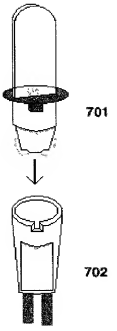


FIG. 7

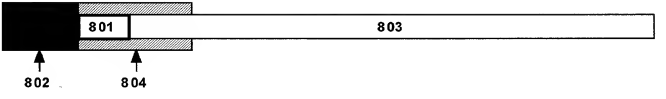


FIG. 8

Please type a plus sign (+) inside this box → [+]

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☒ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	1009.004CIP
First Named Inventor	Mark R. Allen
COMPLETE IF KNOWN	
Application Number	
Filing Date	June 24, 1999
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

PREFERRED EMBODIMENT OF LED LIGHT STRING

(Title of the Invention)

the specification of which
☒ is attached hereto
OR
☐ was filed on (MM/DD/YYYY) ____ as United States Application Number or PCT International

Application Number ____ and was amended on (MM/DD/YYYY) ____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)
60/119,804	02/12/99

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)
09/141,914	08/28/98	

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith ☐ Customer Number OR ☐ Registered practitioner(s) name/registration number listed below → Place Customer Number Bar Code Label here

Name	Registration Number	Name	Registration Number
Gerard J. Weiser Cheryl R. Figlin	19,763 39,562	J. Bruce Schelkopf	43,901

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto

Direct all correspondence to ☒ Customer Number or Bar Code Label 022469 OR ☐ Correspondence address below

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Country		Telephone		Fax	

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
Mark R.	Allen

Inventor's Signature	Mark R. Allen					Date	6/21/99
Residence City	La Jolla DMA 6/21/99	State	CA	Country	U.S.	Citizenship	U.S.
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Post Office Address	~~Suite 310A~~ DMA 6/21/99						
City	La Jolla	State	CA	ZIP	92037	Country	U.S.

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

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